BLM3022 - Computer Networking Technologies

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WEEK 2

1 Routing Algorithms

Routing is the process of discovering network paths

- Model the network as a graph of nodes and links.
- Decide what to optimize (fairness, efficiency).
- Update routes for changes in topology (failures).

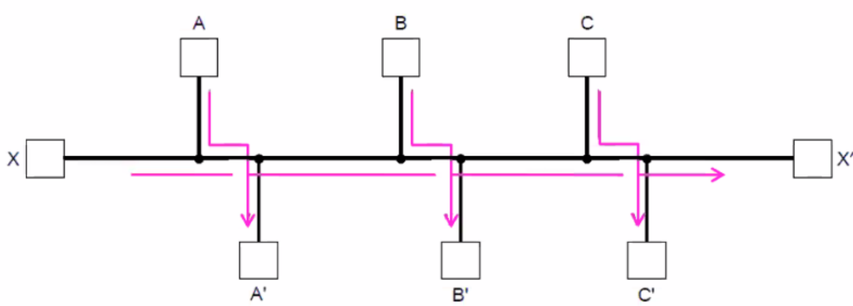


Figure 1: Forwarding.

Forwarding is the sending of packets along a path.

1.1 The Optimality Principle

Each portion of a best path is also a best path; the union of them to a router is a tree called the sink tree. The topology has more than one sink tree, for each host.

- Best means fewest hops in the example.

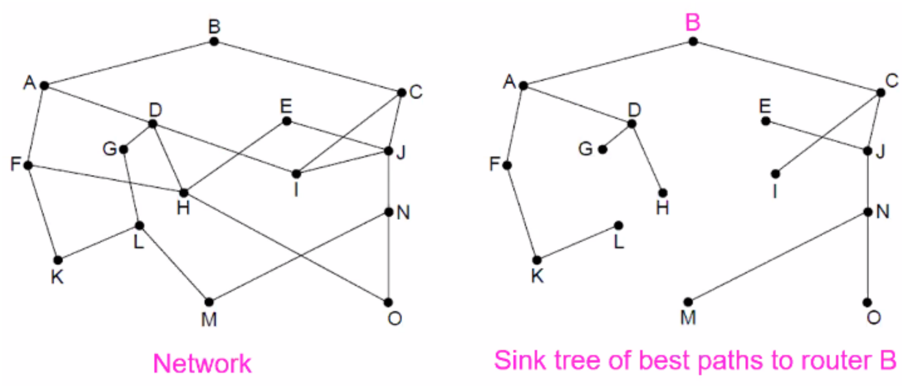


Figure 2: Sink tree.

1.2 Shortest Path Algorithm

Dijkstra's algorithm computes a sink tree on the graph:

- Each link is assigned a non-negative weight/distance.
- Shortest path is the one with lowest total weight. (not just a kilometer, its more about cost)
- Using weights of 1 gives paths with fewest hops.

Algorithm:

- Start with sink, set distance at other nodes to infinity.
- Relax distance to other nodes.
- Pick the lowest distance node, add it to sink tree.
- Repeat until all nodes are in the sink tree.

1.3 Flooding

A simple method to send a packet to all network nodes. Each node floods a new packet received on an incoming link by sending it out all of the other links. Nodes need to keep track of flooded packets to stop the flood; even using a hop limit can blow up exponentially. (baseline method $\rightarrow$ never look at that where did the packet come from. It is negligible that if the source is A, B can send it to A or B. But if the current node is D, then there can be 4 source to send the packet again.)

1.4 Distance Vector Routing

Distance vector is a *distributed* (divide and conquer, like clusters) routing algorithm. Shortest path computation is split across nodes. We know the topology well (Bellman - Ford algorithm).

- Each node knows distance of links to its neighbors.
- Each node advertises vector of lowest known distances to all neighbors.
- Each node uses received vectors to update its own. (flooding but controllable)
- Repeat periodically.

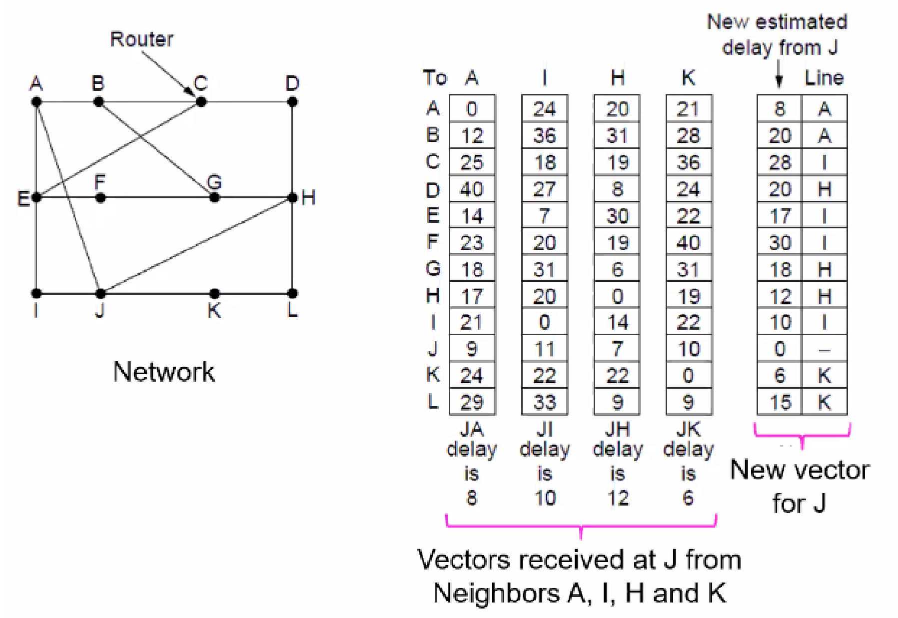


Figure 3: Distance Vector Routing.

1.4.1 The Count-to-Infinity Problem

Failures can cause distance vector to ”count to infinity” while seeking a path to an unreachable node. (distance >= 16 → infinity)

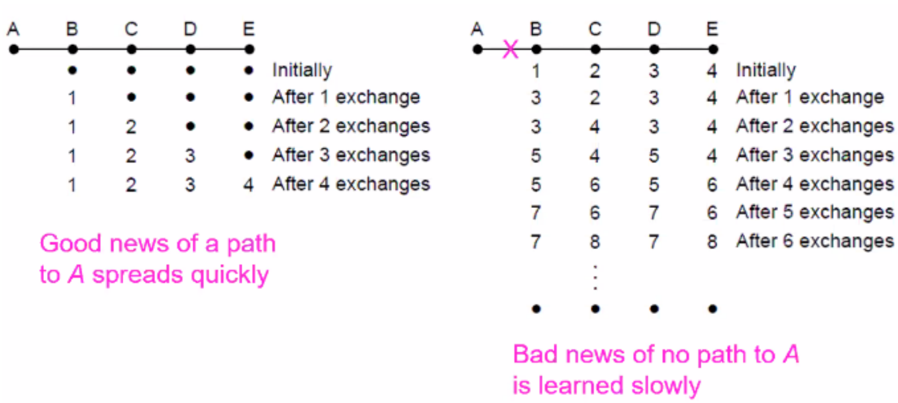


Figure 4: Count-to-Infinity.

1.5 Link State Routing

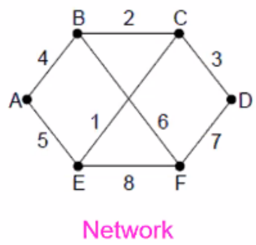
Link state is an alternative to distance vector.

- More computation but simpler dynamics.
- Widely used in the Internet (OSPF, ISIS).

Algorithm:

- Each node floods information about its neighbors in LPSs (Link State Packets); all nodes learn the full network graph. (flood + sink tree)
- Each node runs Dijkstra’s algorithm to compute the path tp take for each destination. (sink tree)

LSP for a node lists neighbors and weights of links to reach them.



A	B	C	D	E	F
Seq.	Seq.	Seq.	Seq.	Seq.	Seq.
Age	Age	Age	Age	Age	Age
B 4	A 4	B 2	C 3	A 5	B 6
E 5	C 2	D 3	F 7	C 1	D 7
	F 6	E 1		F 8	E 8

LSP for each node

Figure 5: LSP.

1.5.1 Reliable Flooding

Seq. number and age are used for reliable flooding.

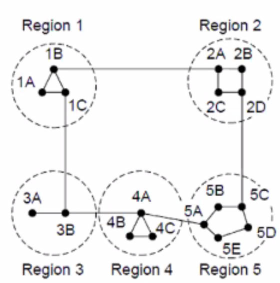
- New LSPs are acknowledged on the lines they are received and sent on all other lines.
- Example shows the LSP database at router B

			Send flags			ACK flags			
Source	Seq.	Age	A	C	F	A	C	F	Data
A	21	60	0	1	1	1	0	0	
F	21	60	1	1	0	0	0	1	
E	21	59	0	1	0	1	0	1	
C	20	60	1	0	1	0	1	0	
D	21	59	1	0	0	0	1	1	

Figure 6: LSP.

1.6 Hierarchical Routing

Hierarchical routing reduces the work of route computation but may result in slightly longer paths than flat routing.



Full table for 1A

Dest.	Line	Hops
1A	–	–
1B	1B	1
1C	1C	1
2A	1B	2
2B	1B	3
2C	1B	3
2D	1B	4
3A	1C	3
3B	1C	2
4A	1C	3
4B	1C	4
4C	1C	4
5A	1C	4
5B	1C	5
5C	1B	5
5D	1C	6
5E	1C	5

Hierarchical table for 1A

Dest.	Line	Hops
1A	–	–
1B	1B	1
1C	1C	1
2	1B	2
3	1C	2
4	1C	3
5	1C	4

Best choice to reach nodes in 5 except for 5C

Figure 7: Hierarchical Routing.

1.7 Broadcast Routing

Broadcast sends a packet to all nodes.

- RPF (Reverse Path Forwarding): send broadcast.
- Alternatively, can build and use sink trees at all nodes.

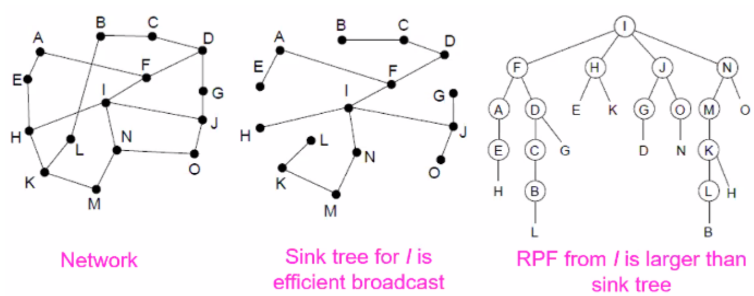


Figure 8: Broadcast Routing.

1.8 Multicast Routing - Dense

Multicast sends to a subset of the nodes called a group.

- Uses a different tree for each group and source.

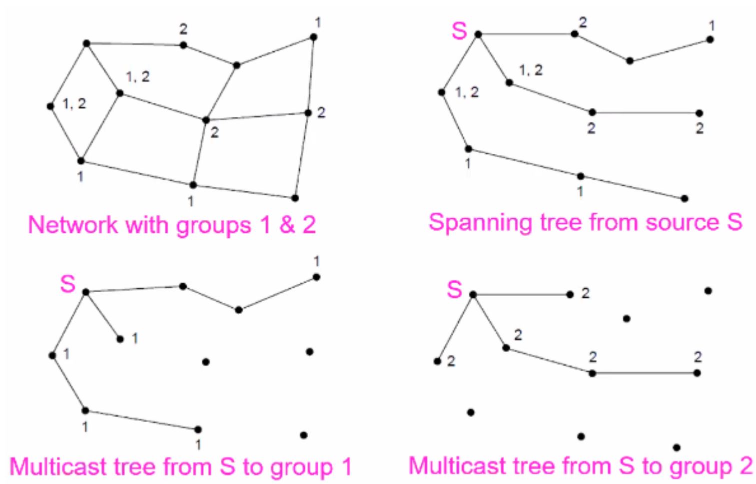


Figure 9: Multicast Routing.

1.8.1 Sparse Case

CBT (Core Based Tree) uses a single tree to multicast.

- Tree is the sink tree from core node to group members
- Multicast heads to the core until it reaches the CBT.

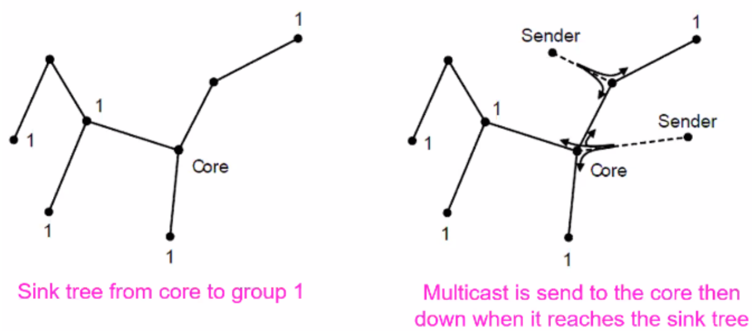


Figure 10: Multicast Routing - Sparse Case.

1.9 Anycast Routing

Anycast sends a packet to one (nearest) group member. (lecturer to one random student example)

- Falls out of regular routing with a node in many places

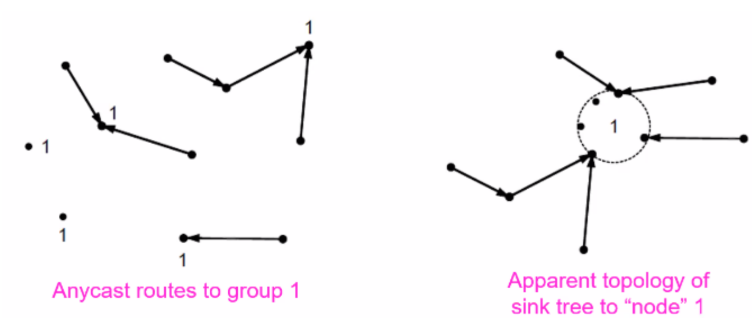


Figure 11: Anycast Routing.

1.10 Routing in Ad Hoc Networks

The network topology changes as wireless nodes move.

- Routes are often made on demand (AODV, below)

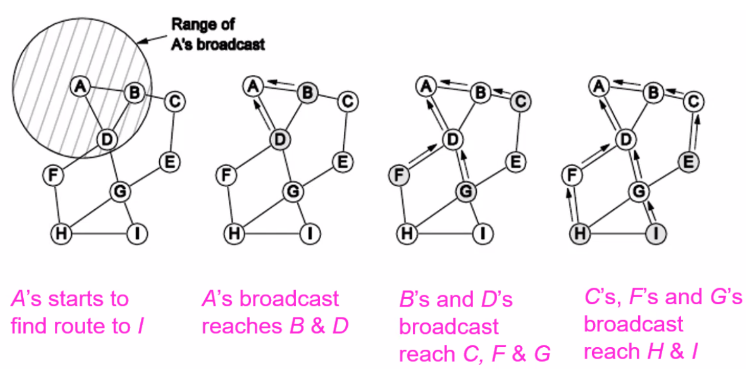


Figure 12: Routing in Ad Hoc Networks.